| | Learning outcomes | Additional guidance |
|---|---|---|
| | *Learners should be able to demonstrate and apply their knowledge and understanding of:* | |
| (a) | kinetic energy of an object; $E_k = \frac{1}{2}mv^2$ | Learners will also be expected to recall this equation and derive it from first principles. *M0.5* |
| (b) | gravitational potential energy of an object in a uniform gravitational field; $E_p = mgh$ | Learners will also be expected to recall this equation and derive it from first principles. |
| (c) | the exchange between gravitational potential energy and kinetic energy. | HSW5, 6 |

(6) M - Recall and apply the equations for KE and GPE
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## KE and GPE

nulation

**STARTER:** Sketch a graph each of these energy types during skating from one side to the ot

a) GPE b) Kinetic c) total energy

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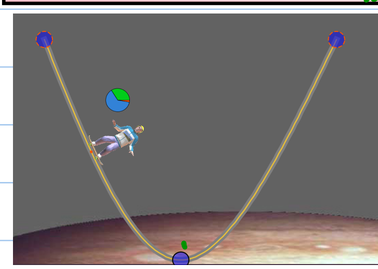
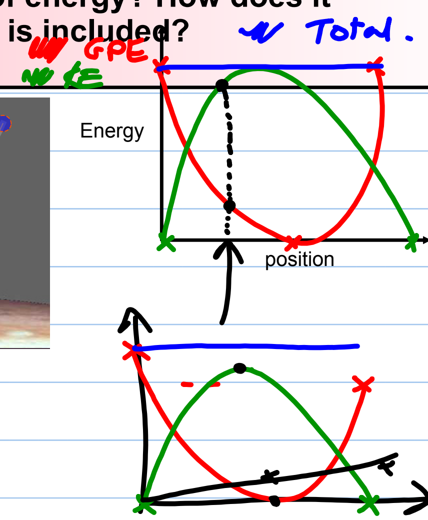
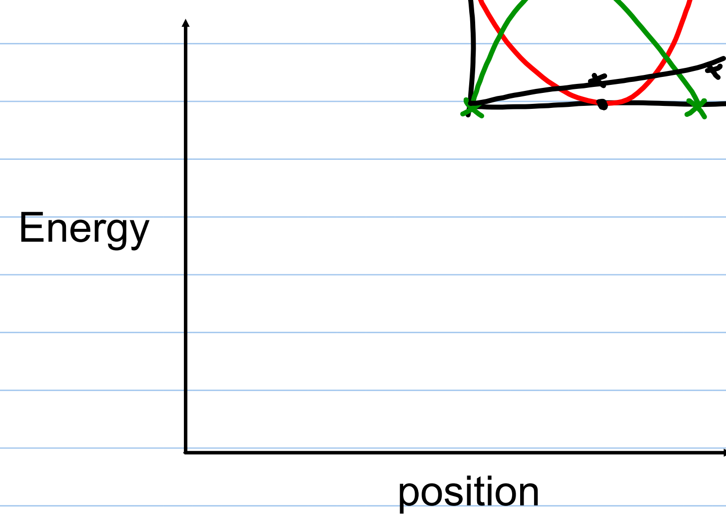
**Extension: Explain how the graph shows the law of conservation of energy? How does it change when friction is included?**





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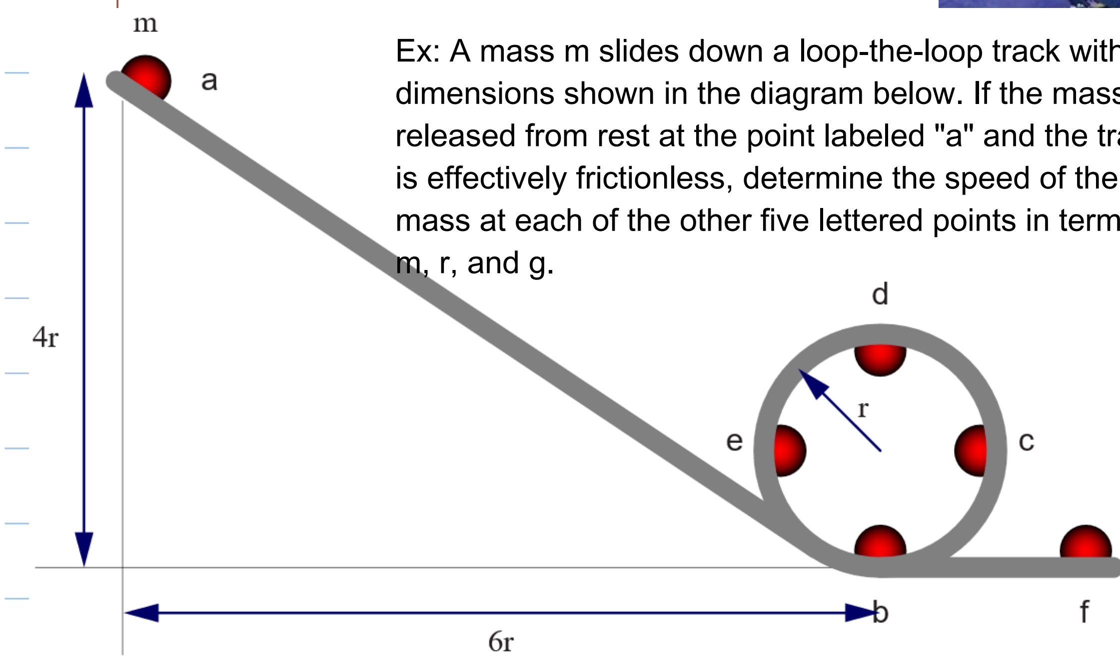
## KE and GPE

Recall the equations for a) KE b) GPE state the quantities and units.

**Activity:** Felix Baumgartner set the world skydiving record in october 2012 for falling from a height of 39 045m His mass (with gear) was 118Kg

1. Calculate his maximum theoretical speed upon landing.
2. Felix reached a speed of 370m/s. What is the ratio of KE measured / KE Max. Comment on the value.

Ex: A mass m slides down a loop-the-loop track with the dimensions shown in the diagram below. If the mass is released from rest at the point labeled "a" and the track is effectively frictionless, determine the speed of the mass at each of the other five lettered points in terms of m, r, and g.



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## Mini plenary


Recall the equations for a) KE b) GPE state the quantities and units.

**Activity:** Felix Baumgartner set the world skydiving record in october 2012 for falling from a height of 39 045m His mass (with gear) was 118Kg

1. Calculate the gravitational potential energy transferred during the fall.
2. Felix reached a speed of 370m/s. Calculate his KE at this speed.
3. Comment on both answers.

spider man

Watch the video below before beginning this problem. The height of the building Spider-Man (a.k.a. Peter Parker, a.k.a. Tobey McGuire) starts off on is 6 stories, or 18 meters high (assuming one story is 3 meters). The height of the building he wants to swing to is 1 story, or 3 meters high. The crane onto which he shoots his web is 7 stories, or 21 meters high. Tobey McGuire is 1.75 m tall and approximately 72 kg in mass. (Do not use the equations of motion to solve any part of this problem.)

Determine…

1. Spider-Man's speed when his feet touch the roof the second building
2. the maximum tension in Spider-Man's web during this video clip
3. the approximate kinetic energy dissipated when Spider-Man struck the wall

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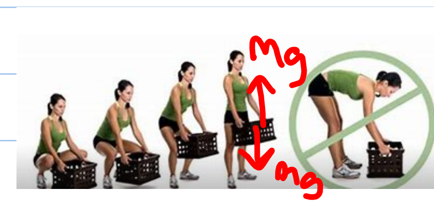
**Deriving the GPE equation**

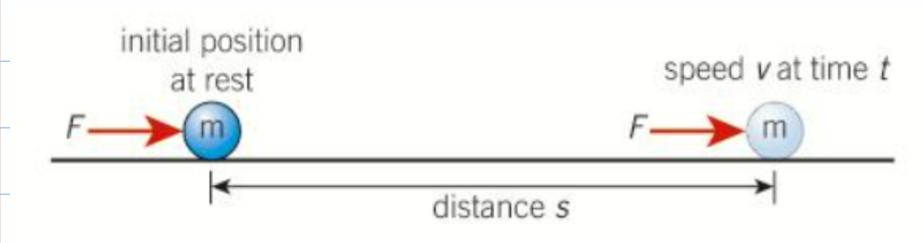
In raising an object upwards in gravitational field, work is done. This work is equal to the energy gained (GPE)

Ep = W = F x distance move in the direction of the force

$E_p = m \times g \times h$




**Deriving the KE equation**




constant force acting on a mass, after time t and distance s it has speed v.

$V^2 = \cancel{u^2} + 2as$

$S = \frac{V^2}{2a}$

suvat

Work done by force is transferred to KE

$W = F \times s = \frac{Fv^2}{2a} = \frac{m\cancel{a}v^2}{2\cancel{a}} = \frac{1}{2}mv^2$

Force = mass x acceleration...

Extension: Use the KE equation to derive the base unit for KE.

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**Energy exchange demo**

In this situation GPE is transferring into KE as the ball falls.

M=

h=

structured worksheet for this...

GPE = KE

$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$gh = \frac{1}{2}v^2$

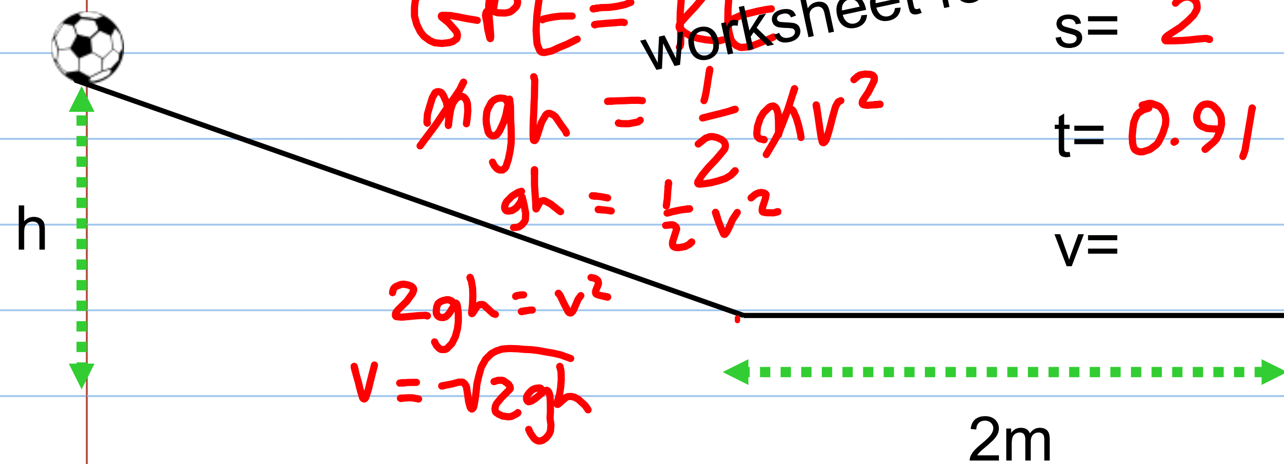
$2gh = v^2$

$v = \sqrt{2gh}$

s= 2

t= 0.91

v=




**Predict by calculation** the exit speed at the bottom of the ramp. $v = 3.57\ ms^{-1}$

**Measure** the exit speed. V= 2.19

**Extension: What** is the percentage difference between the values? Can you suggest 3 reasons for any difference?

- friction does work to reduce speed of ball.
- Energy loss in bouncing
- No accounting for deceleration.

GPE = KE

$\cancel{m} \times g \times h = \frac{1}{2}\cancel{m} \times v^2$

$2gh = v^2$

$v = \sqrt{2gh}$

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**Try the summary questions 1-7 P78**

# Plenary Q

**8** Dan has a mass of 62 kg. He is travelling at a speed of 11 m s$^{-1}$ at the top of a rollercoaster loop, which is 21.8 m above the ground.

**a** Calculate:

**i** his kinetic energy at the top of the loop (*1 mark*)

**ii** his change in gravitational potential energy between the top and bottom of the loop 0.8 m above the ground (*2 marks*)

**iii** his kinetic energy at the bottom of the loop, stating any assumption you have made in calculating your answer (*3 marks*)

**iv** his speed at the bottom of the loop. (*2 marks*)

# Answers

**8 a i** $E_K = \frac{1}{2}mv^2 = \frac{1}{2}(62\text{ kg})(11\text{ m s}^{-1})^2 = 3751\text{ J} = 3.8\text{ kJ}$ (two significant figures) (*1 mark*)

**ii** $\Delta E_P = mg\Delta h$

$= (62\text{ kg})(9.81\text{ m s}^{-2})(21.8\text{ m} - 0.8\text{ m})$ (*1 mark*)

$= 12\,772\text{ J} = 13\text{ kJ}$ (two significant figures) (*1 mark*)

**iii** $E_K$ at bottom of slide = $E_K$ at top of slide + $E_K$ gained going down slide

**or** $E_K$ at bottom of slide = $E_K$ at top of slide + decrease in $E_P$ going down slide (*1 mark*)

Assumption: increase in kinetic energy going down slide is equal to the decrease in $E_P$ going down slide, assuming frictional forces are negligible. (*1 mark*)

$E_K = 3750\text{ J} + 12\,800\text{ J} = 16\,550\text{ J} = 17\text{ kJ}$ (two significant figures) (*1 mark*)

**iv** $E_K = \frac{1}{2}mv^2$

$= \frac{1}{2}(62\text{ kg})\,v^2$

$= 16\,600\text{ J}$ (*1 mark*)

$v = \sqrt{2\times\frac{16\,600\text{ J}}{62\text{ kg}}}$

$= 23\text{ m s}^{-1}$ (two significant figures) (*1 mark*)

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## MC plenary

A ski jumper of mass 50.0 kg uses a launch track as shown in the figure. The initial drop in height is 40.0 m down a ramp and then the skier travels back up a launch ramp regaining 10.0 m of height before taking off. The total length of the launch track is 200 m, and the air resistance and contact with the ice cause an average frictional force of 10.0 N throughout the length of the track.

Calculate the launch speed of the skier as they leave the ramp.

Acceleration due to free fall = $9.81\ \mathrm{m\,s^{-2}}$

22.6

- $26.6\ \mathrm{m\,s^{-1}}$
- $28.0\ \mathrm{m\,s^{-1}}$
- $22.6\ \mathrm{m\,s^{-1}}$
- $24.3\ \mathrm{m\,s^{-1}}$